

**GEOLOGY OF EUROPA: INITIAL GALILEO IMAGING RESULTS.** R. Greeley<sup>1</sup>, R. Sullivan<sup>1</sup>, K.C. Bender<sup>1</sup>, M.J.S. Belton<sup>2</sup>, M. Carr<sup>3</sup>, C. Chapman<sup>4</sup>, B.E. Clark<sup>11</sup>, S.A. Fagents<sup>1</sup>, P.E. Geissler<sup>5</sup>, J.W. Head<sup>6</sup>, K.S. Homan<sup>1</sup>, T. Johnson<sup>7</sup>, K. Klaasen<sup>7</sup>, J. Klemaszewski<sup>1</sup>, A.S. McEwen<sup>5</sup>, J.M. Moore<sup>8</sup>, G. Neukum<sup>9</sup>, R.T. Pappalardo<sup>6</sup>, C.B. Phillips<sup>5</sup>, C. Pilcher<sup>10</sup>, D. Senske<sup>7</sup>, P.C. Thomas<sup>11</sup>, and the SSI Team, <sup>1</sup>*Dept. of Geology, Arizona State University, Tempe, AZ 85287-1404*, <sup>2</sup>*NOAO, Tucson, AZ*, <sup>3</sup>*USGS, Menlo Park, CA*, <sup>4</sup>*SW Res. Inst., Boulder, CO*, <sup>5</sup>*LPL, Tucson, AZ*, <sup>6</sup>*Brown Univ., Providence, RI*, <sup>7</sup>*Jet Propulsion Laboratory, Pasadena, CA*, <sup>8</sup>*NASA Ames Research Ctr., Moffett Field, CA*, <sup>9</sup>*DLR, Berlin, Germany*, <sup>10</sup>*NASA Headquarters, Washington, DC*, <sup>11</sup>*Cornell Univ., Ithaca, NY*

**Summary:** The first 4 orbits of the Galileo spacecraft around Jupiter have returned pictures of Europa ranging in resolution from 6.9 km/pixel global views to 26 m/pixel images of small areas, as well as new color data for representative terrains and surface features. The best Voyager (VGR) coverage was only 1.8 km/pixel in a very limited area. Average VGR resolutions are 12 to 20 km for most of the surface, making Europa the least understood of the Galilean satellites. The new Galileo data [1] show details and characteristics of the surface including evidence for geologically recent endogenic resurfacing.

**Craters:** Several impact craters have been discovered in the Galileo data. These include a 30-km diameter crater provisionally named Manann'an, centered at 240W, 2N; and Pwyll, a 50-km diameter crater centered at 271W, 26S, previously suggested to be a crater based on VGR data [2]. Several areas on Europa show numerous small (<5 km) impact craters, some of which have bright ejecta, others of which have dark ejecta. In addition, low sun illumination shows that some terrains contain dozens of circular to irregular depressions <10 km in diameter. These could be of impact origin, although many might alternatively be of endogenic origin. The lack of these possible impact features in other areas observed at comparable image resolution and illumination would then suggest either significant differences in surface ages or in the structure of the icy crust.

**Tectonic features:** Tectonic features identified on VGR data include grey bands, wedge-shaped bands, and lineae and ridges of different forms. These and other features are seen in much greater detail with Galileo data. Tectonic features such as fractures are observed to the limit of resolution (26 m wide). Ridges occur in a wide variety of morphologies and range in width from <100 m to 5 km. In high resolution frames, most ridges are seen to have a medial depression. Cross-cutting relations show that many of the youngest ridges have the greatest topographic relief, suggesting some geomorphic process of degradation or relaxation with time. The origin of

the ridges could involve extrusion of ductile ice, intrusions by dikes with subsequent up-warping, and/or buckling by compression of the icy lithosphere along fractures. Global patterns of ridges and other tectonic features have been related to endogenic or exogenic processes, reviewed by Lucchitta and Soderblom [3] and Malin and Pieri [4]; alternatively, they could be related to a relict impact structure [5]. Initial Galileo results, however, show that the patterns of different types of tectonic features and their age relationships are complex and must await additional data for global analyses [6,7].

The anti-jovian hemisphere shows a zone of dark wedge-shaped bands, previously interpreted as "pull-apart" terrain in which icy crustal plates have been separated [8,9,10]. Galileo data show the dark bands consist of parallel ridges and grooves, some of which are bilaterally symmetric, suggesting formation by repeated extrusive emplacement. Individual bright plates range in size from a few km to >50 km across, and can be fit back together [11,12]. The tectonic style represented in the pull apart terrain is akin to sea floor spreading on Earth and is distinct from tectonic resurfacing proposed for Ganymede.

**Possible flow features:** An area centered at 322W, 5N was imaged at 630 m/pixel under low sun illumination. In this area a series of possible viscous flows appears to extend from the west toward the east where the flows were partly blocked by a series of ridges trending north-south some 250 km across the image. In places the flows breached the ridges, forming local lobes 35 km long and 10 to 20 km across. Terrain covered by the flows west of the ridges appears subdued. These are the first flowlike features observed on Europa.

**Macula:** Irregular-shaped low albedo patches on Europa were termed maculae based on Voyager data. One such feature was identified on low resolution (6.9 km/pixel) Galileo data taken on the second orbit and then imaged in high resolution on the fourth orbit at 120 m/pixel resolution. This unnamed feature, centered at 334W,

16S, is about 100 km across and consists of a central oval zone of rugged relief some 50 km across, surrounded by concentric grabens, fractures, and ridges. Patches of smooth terrain 10 by 30 km in size occur within the concentric zone, as do circular depressions 5 to 10 km in diameter. Outward from the concentric zone, the terrain includes criss-crossing ridges and small (~few km) circular pits. This macula is reminiscent of small coronae seen on Venus and could be of either endogenic or exogenic origin. If exogenic (impact), the macula might be analogous to palimpsests seen on Ganymede [7,13]; the central zone could represent the scar of the transient cavity and the craters seen beyond the concentric zone could be preserved secondaries.

The initial results summarized here are based on approximately 1/3 of the total data expected to be returned from the nominal Galileo mission. If approved, the Galileo Europa Mission (GEM) would enable repeated flybys of Europa, returning even more and higher resolution data.

## References

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